MEMOIRS OF THE PEABODY MUSEUM OF YALE UNIVERSITY
VOLUME III · PART 2

A REMARKABLE GROUND SLOTH

BY

RICHARD SWANN LULL

SPECIAL PROFESSOR OF VERTEBRATE PALAEONTOLOGY
AND DIRECTOR OF THE PEABODY MUSEUM

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Photograph by Longwell

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A REMARKABLE GROUND SLOTH

DISCOVERY

On February 25, 1928, a letter was received from Ewing Waterhouse of El Paso, Texas, announcing the discovery of a remarkable animal and inclosing photographs and drawings and asking for information. From the pictures it was at once evident that a ground sloth had been discovered in a marvelous degree of preservation, and negotiations were straightway begun for its purchase for the Peabody Museum at Yale. This was made possible by a grant from the T. Mitchell Prudden Fund for the securing of archaeological material, established by bequest of T. Mitchell Prudden, Ph.B. 1872, and the specimen was shortly received at New Haven. Mr. Leo V. Horton, a Yale alumnus who was at the time in Texas, went at once to El Paso, and it is largely due to his prompt and enthusiastic efforts that the purchase was effected.

As the locality proved to be on public domain, the aid of United States Senator Hiram Bingham of Connecticut was invoked to clear our title to the specimen, and by his good offices the Department of the Interior, upon the recommendation of the authorities of the United States National Museum, granted the Peabody Museum full right of possession. The privilege of further exploration of the immediate locality, together with the surrounding region, has been granted jointly to the Peabody Museum and the National Museum. The cordial coöperation of the Department of the Interior and of Messrs. Wetmore and Gilmore of the National Museum is deeply appreciated at Yale.

LOCALITY

The remarkable specimen discussed in this memoir comes from Dona Ana County, New Mexico, some ninety miles by road and forty-five directly northwest of El Paso, not far from the little town of Aden. In August, 1928, Prof. Chester R. Longwell of Yale, guided by Waterhouse, made a reconnaissance of the region and descended into the sloth pit, seeing for himself the conditions under which the specimen was preserved. An extract from his report to the Director of the Museum follows:

> The sloth was found at an extinct volcanic crater 4 miles south of the Southern Pacific Railroad between Deming, New Mexico, and El Paso, the precise locality being indicated on the accompanying map (Fig. 1). The crater is one of several volcanic features of the region in which basaltic lava is widespread, constituting the only rock exposed within a radius of many miles. While there are several more or less distinct craters and a number of especially prominent lava flows in the general area, some of which appear to be very recent geologically, the Aden Crater is the only striking feature of this kind in the immediate vicinity and hence is readily identified.
>
> The Aden Crater rises somewhat less than 200 feet above the surrounding plain, with a rather abrupt and very rugged rim. This rim encloses an area about a quarter of a mile across, the floor of which is nearly flat and lies 20 to 40 feet below. The floor has, in places, a thin soil

covering in which grow scattered cacti and other desert plants. Near the center lies a funnel-shaped pit, probably the result of the last activity of the volcano. A general view of the crater from without is shown in Pl. I, A.

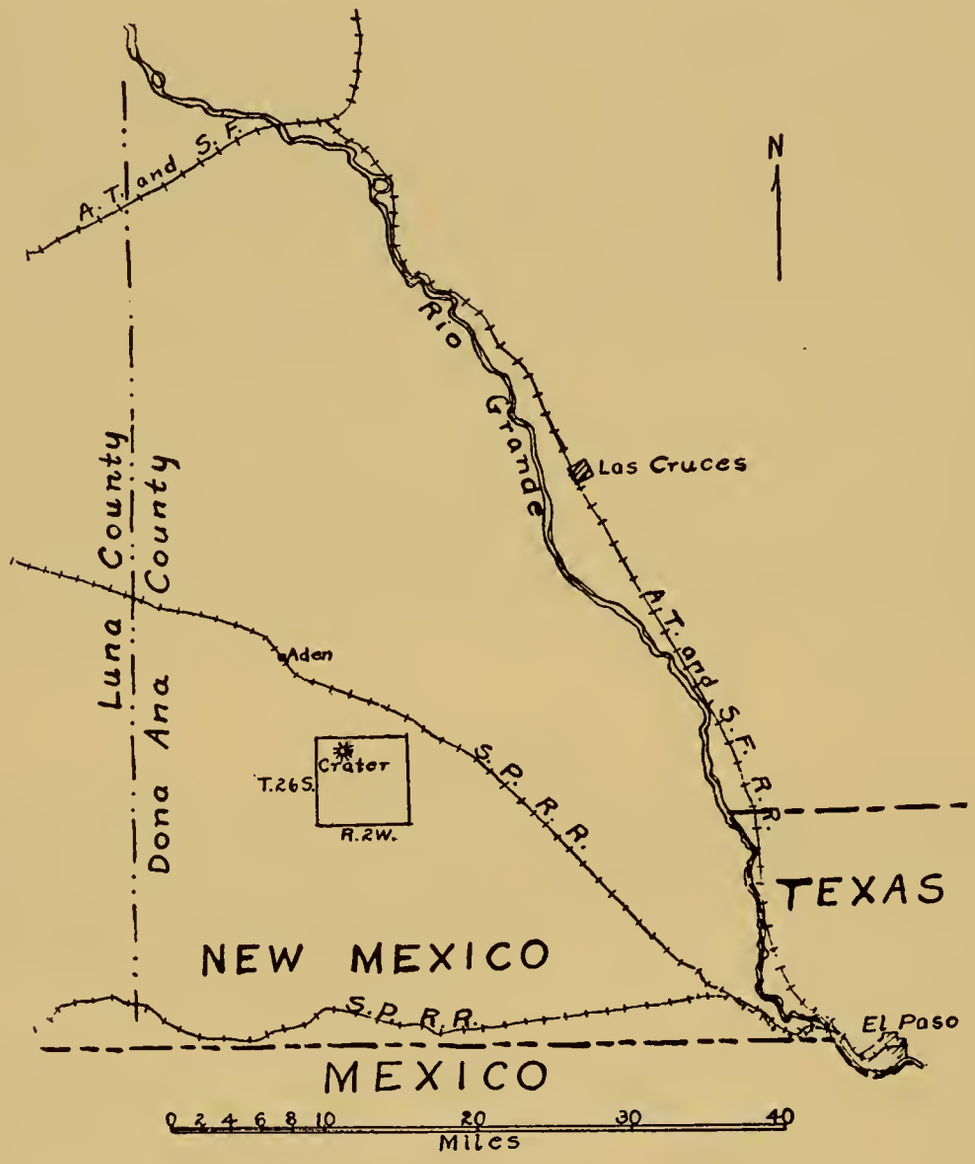

Fig. 1. Map to show the location of Aden Crater.

General features traced from the topographic map of New Mexico, U.S. Geological Survey, 1925. Approximate position of sloth pit is on eastern rim of crater. *After Longwell.*

On the east side of the crater the outer rim is pierced by a narrow breach which seems to form a convenient opening to the interior of the crater and doubtless has served as such to numerous animals in the past (see Pl. I, B). But this apparent haven of refuge proves to be a most appalling death trap, for right across the floor, occupying the entire width of the runway, lies the opening into the pit itself. This opening has a maximum diameter of 8 feet, is irregularly oval in form, and leads down almost vertically into the darkness below. The skeleton of the sloth was found in the depths of this natural pit, into which the animal had fallen, for a hurrying creature which could not jump the opening would have little chance of avoiding this catastrophe. An alternative explanation is that there may have been at one time another passage into the pit, now entirely obliterated, into which the sloth wandered and from which he was prevented from emerging by the caving in of the roof of the passage. This would account for the lack of any broken bones, which would almost inevitably have resulted from a vertical fall.

The re-fused character of the walls of the sloth pit indicates its nature, namely, that it is the opening of an old fumarole and thus formerly subject to intense heat.

The descent into the pit is difficult, as it is necessary to use a rope, taking advantage of occasional irregularities in the wall for foot rests. The descent is nearly vertical for the first forty feet (see Fig. 2). From the first landing the pipe continues down irregularly by a series of steep slopes, nearly horizontal stretches, and vertical drops, and the diameter varies greatly. Fifty feet below the surface there is a large cavernous chamber, from which two passages lead down, one vertically, the other by a tortuous route. These passages converge about twenty-five feet below in another chamber twenty or thirty feet across. The floor of this room is sloping and is heaped high with bat guano, the accumulation of centuries.

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Several blind openings start downward from this chamber; but the main passageway leads downward by a moderate slope to a second large room some fifteen feet in width by thirty in length. This also contains a large quantity of bat guano. The sloth skeleton was found on the floor of this room, almost completely buried in the dry, loose guano, and at a distance of about one hundred feet vertically below the mouth of the pit. A short distance below the sloth chamber is another enlargement of the fumarole pipe, below which the opening is effectively closed.

Skeletons of coyotes, a bobcat, and other animals were found lying on top of the guano, apparently recent victims of the death trap. The sloth, together with such other animals as may be found buried in the guano, is evidently much older, as it has Pleistocene affinities. Any creature which falls into the opening of the pit is doomed, as escape by any means other than flight seems utterly impossible. From the size of the opening, however, our specimen is about the largest animal which would be caught. The chance of finding a *Megatherium* or even a *Mylodon* preserved in the guano seems remote. Nevertheless our projected exploration of the cavern may yield interesting results, among others the finding of the fellow victim that gnawed most of the hide from the body of the sloth, leaving teeth marks that are still plainly visible.

Falling into the pit would not necessarily result in broken bones, as the sloth with his large claws probably retarded his fall by clinging to irregularities in the walls. After he reached the first landing forty feet down, he may have descended the remainder of the way of his own accord while searching for a means of escape. He could not, however, ascend unaided even from the first landing.

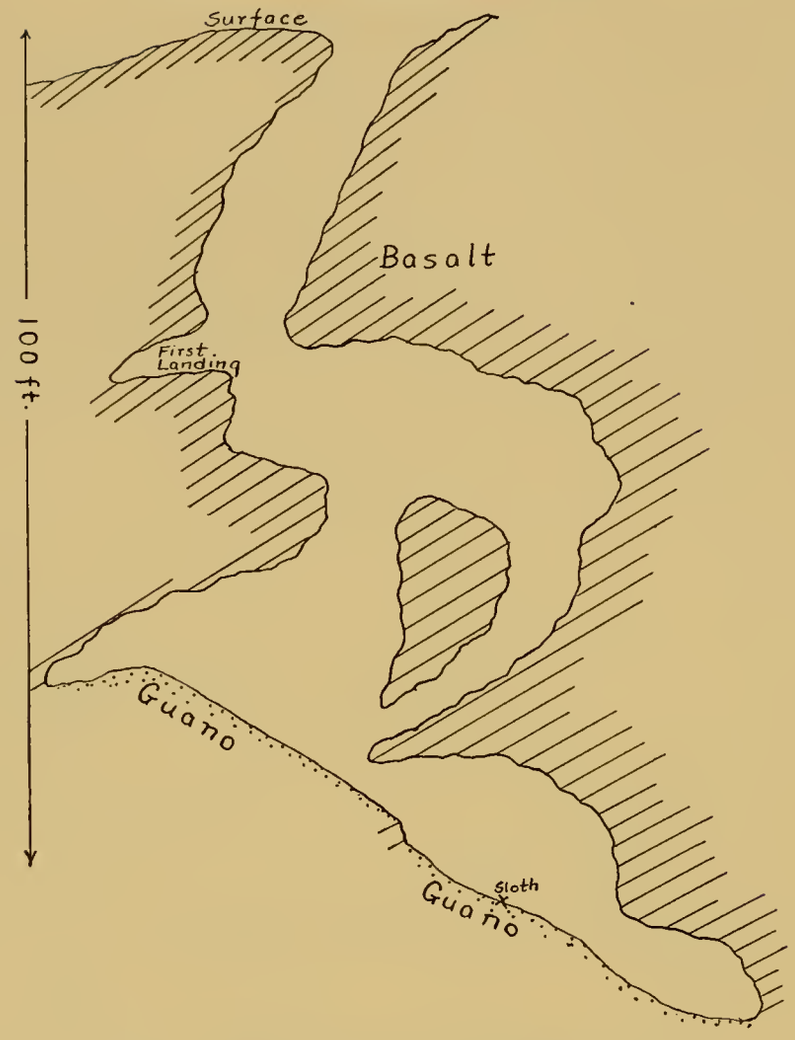


Fig. 2. Rough vertical section of sloth pit.

The direction changes somewhat from top to bottom to allow for the tortuous course of the old pipe. At the top the section cuts from east to west and represents what the observer would see looking south; at the bottom the observer is assumed to be facing southeast. Dimensions given are estimated. *After Longwell.*

GEOLOGICAL AGE

The sloth, which has been determined as pertaining to the species *Nothrotherium shastense* Sinclair, is undoubtedly Pleistocene, as the species is found in the Rancho la Brea asphalt associated with *Mylodon harlani, Elephas jeffersoni, Camelops hesternus, Equus pacificus, Smilodon californicus, Felis bebbi, Aenocyon dirus,* and other forms of mid-Pleistocene age. On the other hand, its amazing condition of preserva-

tion gives one the feeling that it cannot be more than a few hundreds of years old. The half billion years that the mid-Pleistocene implies seems almost unthinkable.

Again, the topography of the region cannot materially have altered since the sloth was trapped, otherwise it is doubtful if he would have been. But the climate is dry, the rock extremely obdurate, and erosion proportionately slow. There is absolutely no way of determining the geologic age other than by correlation of the fauna with that of the Rancho la Brea, for instance, and, while we have but a single specimen, there is always the possibility of individual survival. Perhaps the contents of the sloth's coprolite, to be described later and including determinable plant remains, may throw additional light upon the question of age. The contained vegetation is typical of today—sagebrush and other herbaceous plants but no cacti. The absence of the last may, however, imply merely discrimination on the sloth's part. Otherwise the botanical evidence again points to little or no climatic change.

CONDITIONS OF PRESERVAL

THE specimen was complete, the bones being held in articulation by their original ligaments and tendons. There are also present some of the periosteum, patches of skin, and the mucous membrane lining the hard palate, as well as some muscle fibers. Apparently, as we have seen, a greater part of the hide was devoured by fellow victims, as the marks of rodent-like teeth are visible, including certain scorings of the skull itself. The claws are also preserved. The left ribs and scapula and the left side of the skull are somewhat decayed. This side, as I understand it, was downward as the creature lay in the guano. Apparently the moisture of the body which accumulated in the lower side of the animal as it lay is responsible for this disintegration, as it did not affect the remaining portion of the left limbs. That the guano was the means of preservation seems obvious, together with the general dryness of the cavern. To what extent the sloth was buried in the guano and how much was covered by later accumulation as it lay is not clear. A few protruding ribs gave evidence of its presence.

ASSOCIATED MATERIAL

AT this writing nothing has come to light that was actually contemporaneous with the sloth, the bobcat and coyotes being obviously later, probably much later, as they are recent geologically. The only other associated object was the coprolite, or food ball, mentioned above, which lay either in the rectum or was extruded with the relaxation of the animal at death.

EXTENT OF MATERIAL

THE specimen is exceptionally perfect, the only missing parts being the corroded portions, rib ends, and so forth, the tip of the tail, the left patella, several sternebrae

and sternal ribs, and certain epiphyses. The Rancho la Brea has yielded sufficient material of this rare genus to permit the mounting of a composite specimen of remarkable accuracy. But it is made up of several individuals, and the bones do not always show the correct proportions, whereas the Yale specimen is a single individual, which eliminates this source of error. Judging from proportionate measurements, ours represents an animal about nine-tenths grown. Mr. Stock is to be congratulated, not only for the splendid mount in the Los Angeles Museum, but also for his highly accurate interpretation of the several elements (1913, 1925). His work is so detailed that a comparative study of the present specimen is all that is necessary.

MORPHOLOGY

ENDOSKELETON

AXIAL SKELETON

The Skull (Pl. III; Text Figs. 3–5).—The skull and jaws are well preserved on the right side but on the left are somewhat decayed. A portion of the hide 240 mm. long covers the nasals, frontals, part of the parietals and maxilla of the right side, thus concealing the mid-line sutures and full length of the nasals. On the right side of the muzzle are vague traces of hair. The palate also bears some of the soft parts, as do the premaxillaries and turbinals. A portion of muscular tissue is also present between the skull and the ascending ramus of the jaw on the left.

As the table of measurements (page 9) shows, the Yale skull is smaller than any of the several *Nothrotherium* skulls described by Stock in his memoir. This may be due to the relative immaturity of the present specimen, as it is true of almost every comparable measurement of the skeleton. The Yale skull varies, however, in its relative slenderness and comparatively high occiput and length of palate. To what extent these are juvenile characters is not evident. The ratios of length to breadth across the cranium are for *Nothrotherium texanum* type U.S.N.M. No. 8353, 285 to 100; *N. shastense* Rancho la Brea, average of six skulls, 300 to 100; Yale skull, 330 to 100. In profile the Yale skull is decidedly more arched at the vertex and less flaring at the muzzle, so that the facial contour is markedly different. In the latter detail there is much variation within the Rancho la Brea group, and the arching of the nasals also varies. These details of contrast, therefore, may well fall within the range of individual variation or be due to age or sex and hence of no value for specific diagnosis. The lachrymal is prominent, viewed from above, and the lachrymal canal is large. The postorbital process of the frontal is almost obsolete. There is a marked depression of the frontals above these processes. This feature also varies within the Rancho la Brea group, being most marked in the largest individuals and practically absent in the type of Stock's abandoned species of *N. graciliceps*, Los Angeles Collection Nos. 1800–13. There is no trace of temporal ridges in our specimen, and a sagittal crest is only slightly indicated. There is a sag or depression in the median profile of the an-

terior third of the parietals, a feature which also varies in Stock's material until it is hardly discernible in some.

The zygomatic process of the squamosal of the Yale skull is long and slender, as in *N. shastense,* but is slenderer at the anterior end with more of a gap between it and the malar. This again may be a juvenile character. The malar also differs in minor details, the dorsal process being longer and slenderer, while of the ventral prong the reverse is true. In most of the Rancho la Brea specimens the antero-external angle of the parietal meets the alisphenoid. Occasionally, however, it does not, nor does it in the Yale skull.

Fig. 3

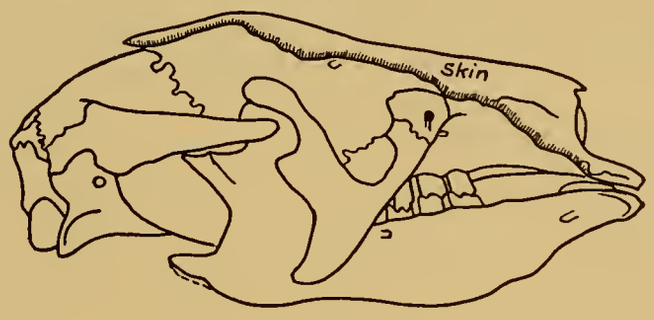
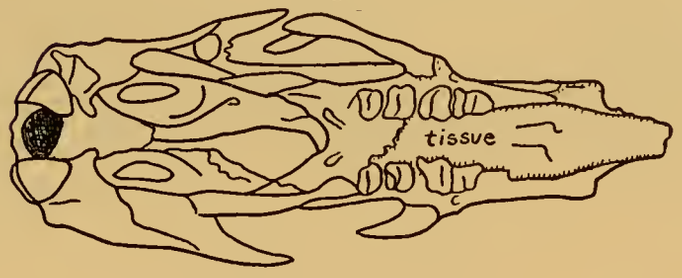


Fig. 4

Fig. 5



PREMAXILLARIES.—The premaxillaries (Figs. 3, 4, 5, Plate III), although originally present in the Rancho la Brea specimens, unfortunately have not been found in the collections. In our skull they are present but are obscured by the soft parts below and somewhat from above. Posteriorly they have a broad bearing upon the maxillaries,

the hinder part extending halfway up the sides of the muzzle. Viewed vertically, they swing forward in a marked curve and are slender anteriorly, somewhat as in the Santa Cruz genus *Hapalops* from South America. As in Scott's figure of the latter, the tip of the right premaxillary is slightly in advance of that of the left. Stock's description of the muzzle of *N. shastense* is in entire agreement with our skull, and the same is true of the palate, as far as can be seen because of the obscuring soft parts. The pterygoid bullae have large foramina, agreeing with *shastense* but differing from the South American *Nothrotherium* described by Reinhardt. The glenoid surface of the skull has its articulating cartilage preserved. This is decidedly concave longitudinally on the articulating surface, thus inhibiting any fore and aft movement of the mandible. The vomer has a peculiar asymmetrical, longitudinal ridge on its palatal aspect. This starts on the left of mid-line anteriorly, curves widely to the right, then back to the left again. This is shown in Stock's Figure 10 A but not mentioned in the description. (See Fig. 5.)

The mandible in the Yale specimen shows no marked distinction from those of the Rancho la Brea.

Symphyseal Ossicle.—(Fig. 3, Pl. III, A.) There is an ossicle of peculiar structure lying in the spout-like symphysis which for convenience may be called the "symphyseal ossicle." This bore against the premaxillary region of the palate and was used in securing food, taking the place of the lower incisors of ruminants. This hitherto unknown element has been detached from its place at the mandibular symphysis but is clearly revealed *in situ* in some of the photographs taken by Mr. Waterhouse, so there is little question as to its position and orientation. From above it is a pointed ellipse with a somewhat roughened surface. Below, it has a median longitudinal keel dividing the highly rugose surface into two trough-like areas. Posteriorly the ossicle turns down sharply. A broken surface shows a very cancellous structure. Shrunken soft parts on the inner side of the left ramus show a rugose surface which is the reciprocal of part of the under side of the ossicle.

The under surface of the left premaxillary bears a bit of thick, hard, roughened cartilage, which, when fully complete, doubtless bore against the ossicle below. This shows no trace of calcification, however; but if it did, the texture would possibly resemble that of the ossicle.

Hyoid Arch (Pl. III, A).—The right stylohyal is present in the Yale specimen. It does not differ from Stock's description. It was *in situ,* attached to the styloid process of the skull.

MEASUREMENTS*

	Length	Proximal width
Stock, Stylohyal No. 1540	97.4	31.3
Y.P.M. No. 13198	81.0	23.3

* Note: The measurements are in millimeters throughout.

Malleus.—The left malleus has fallen out of the ear opening. It is probable that all of the ossicles of the right side are *in situ*, but the soft parts prevent their study. The malleus is typical, with a rounded head bearing two faces and a slender manubrium. It measures 12 mm. There are no other processes such as one sees in man.

Dentition (Plate III).—Comparing our skull with Stock's Figure 13, the main distinctions are: In the former the teeth are closer together, the second upper molar has a much deeper notch on the occlusal surface, and the anterior crest is much higher than the posterior one. M^5 seems to be of less fore and aft diameter as compared with the others and has a slight vertical groove on its anterior face. In Stock's figure this face is convex. The fore and aft diameters of all the other teeth correspond with the figure, but the transverse diameters are somewhat less. In our specimen the transverse notches are wider toward the outer side; in No. 1800–11 Stock's series the reverse is true; while in 1800–4 the transverse crests are parallel. These distinctions, however, are merely those of wear and are not diagnostic.

SKULL AND JAW MEASUREMENTS

Skull	*N. shastense* R.L.B. Extremes	*N. shastense* R.L.B. Average	*N. texanum* No. 8353 U.S.N.M.	*Nothrotherium* No. 13198 Y.P.M.
Length, maxillae to occipital	302.0–330.0	313	300	287.0+
Width of cranium behind orbits	98.3–112.9	104.4	105	86.0
Ratio of length to width		3.00 : 1.00	2.85 : 1.00	3.3+ : 1.00
Length of palate	127.0–144.0	136.0		135.0
Width of palate	20.6–24.0	22.7		19.4
Height of occiput	76.5–87.7	81.3	80	78.0
Length of nasals	111.9–134.3	121.4	105	98.0
Width of muzzle	65.5–78.2	72.4	71	59.5
Mandible				
Length, symphysis to condyle	260.7–284.4	272.8	Unknown	243.0
Length of symphysis	82.9–90.4	88.2	Unknown	69.5
Depth between 2d and 3d molars	53.0–60.6	56.1	Unknown	51.0
Height, angle to coronoid	101.7–121.4	110.7	Unknown	103.0
Thickness of horizontal ramus at m_3	25.3–29.3	27.3	Unknown	24.0
Ratio of length to height		2.46+ : 1.00	Unknown	2.36+ : 1.00

VERTEBRAL COLUMN

Vertebral Formula.—No complete series of thoracic vertebrae was obtained from the Rancho la Brea. Mr. Stock's estimate of seventeen, however, agrees with the Yale specimen and is therefore correct. The number of caudals cannot be verified from our individual, as the distal ones have not been recovered as yet.

Comparative formulas taken from Stock are:

	Cervical	Thoracic	Lumbar	Sacral	Caudal
Nothrotherium shastense	7	17?	3	5	21
Nothrotherium Y.P.M. specimen	7	17	3	5	12 present
Hapalops longiceps	7	22	3	6	20±
Hapalops elongatus	7	21–22	3–4	5–6	20±
Megatherium americanum	7	16	3	5	17
Myrmecophaga jubata	7	15	3	5	29

Hapalops of the Santa Cruz formation is looked upon as the ancestor of *Nothrotherium*. As Stock says, the reduction of the number of thoracic vertebrae from twenty-two to seventeen is the most fundamental change in the skeleton which has occurred, and in this all Pleistocene ground sloths agree. I should add foot attitude, so clearly indicated in our specimen, as another important change.

The entire vertebral column of the Yale specimen agrees with Stock's description, except for the following details.

Cervical Vertebrae.—The cervicals are relatively slenderer, a juvenile character. The spine of cervical 6 is relatively higher, being two-thirds that of the 7th but slenderer. In Stock's description it is only slightly higher than the 5th; ours is half again as high.

CERVICAL MEASUREMENTS

Atlas	Extremes	Av. of 5	Yale 13198
Greatest transverse width	130.0–153.3	142.9	113.0
Greatest antero-posterior diameter	63.0–69.7	65.4	60.5
4th cervical			
Ventral length of centrum	39.0–49.5	44.8	ca. 41.0 obscured by tissue
Width over anterior face of centrum	36.7–42.0	38.9	ca. 32.0
Greatest width across prezygapophyses	79.2–94.3	87.1	82.3
Height from ventral border of posterior face of centrum to tip of neural spine	ca.65.0–78.0	71.9+	68.0
Articulated cervicals 1 to 7			
Length over all		293.0	ca. 280.0

Thoracic Vertebrae.—The anterior thoracic possesses a large spine. With the Yale specimen the epiphysis of this vertebra is one of the few preserved. Not only is the spine widened antero-posteriorly in both the Rancho la Brea and the Yale specimens, but in the latter the summit of the spine is broadened transversely as well. It also differs in outline, especially posteriorly, from that described by Stock.

THORACIC MEASUREMENTS

Rancho la Brea 1809–1 to 1825–1	1	3	5	7	9	11	13	15	17
Length of centrum	38.0	39.1	38.1	38.7	41.0	43.5	43.9	44.3	47.3
Depth of centrum	24.1	28.3	31.3	34.5	38.2	41.6	44.1	46.3	48.8
Greatest width of centrum		113.7	107.9	113.5	123.4	120.0	132.6	130.0	134.2
Across prezygapophyses		56.1	56.3	59.7		60.5	63.7	70.4	78.7
Total height	128.6	119.0	119.6	121.2	124.5	134.5	140.7	151.8	160.6
Y.P.M. 13198	**1**	**3**	**5**	**7**	**9**	**11**	**13**	**15**	**17**
Length of centrum	ca. 33.0	30.0	31.1	32.5	37.4	38.0	39.0	39.4	43.0
Depth of centrum	29.5				41.9			47.5	46.5
Greatest width of centrum	44.5	?43.4	41.5	43.7	48.0	50.0	51.2	55.0	54.0
Across prezygapophyses					53.5	59.0			64.0
Total height	114.4 epiph.				114.4 est.				114.0 epiph.

One peculiar feature is that in the Yale specimen the total height of the spines does not seem to increase, whereas in the Rancho la Brea material, after the first, the increase is steadily maintained from numbers 2 to 17. This again may be a juvenile trait in the Yale specimen, correlated with less muscular development. The depth of centrum in the Yale specimen is little less than that of Stock's, while the width is less than half.

The presence of dried tissue in the Yale specimen is highly interesting but interferes with precise measurements, such as the depth of the centra.

Lumbar Vertebrae.—The lumbars seem to agree with those of the Rancho la Brea, except for size and proportions, wherein they vary, as do the thoracic vertebrae.

Sacrum.—The sacrals are completely fused in each instance, and their spines form a continuous crest.

Caudal Vertebrae.—The caudals probably were twenty-one in number. The most complete series from Rancho la Brea is sixteen in one specimen, Nos. 1–14, 16, and 18. The Yale specimen now has Nos. 1–12. It is hoped, however, that exploration will complete the series.

In the Rancho la Brea specimens the transverse processes are long in the first two caudals and much shorter in the third of the series and posteriorly. In the Yale specimen the diminution is evenly graded and not abrupt.

Ribs.—There are no points of divergence in either dorsal or sternal ribs. Out of ten pairs of the latter we possess Nos. 1, 3, 4, and possibly 10 of the right side and Nos. 1, 4, and half of another of the left.

Sternum.—With the Yale specimen the manubrium and two other sternals are present. The latter agree in being unsymmetrical pieces of bone. No *Nothrotherium* sternum is complete, but presumably the number of sternebrae was seven, which is normal to other Pleistocene ground sloth genera.

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APPENDICULAR SKELETON

Clavicle.—The clavicles in Stock's description agree with ours, except that the former are decidedly smaller, save in one dimension,* a rather remarkable feature, the reverse of what occurs in nearly every other element of the skeleton.

CLAVICULAR MEASUREMENTS

	Rancho la Brea		Yale
	Extremes	Mean Average	Y.P.M. 13198
Greatest length	136.2–140.6	138.4	171.0
*Greatest width sternal end	32.8–37.3	35.0	30.0
Greatest thickness sternal end	20.0–24.6	22.3	26.7
Width mid-shaft	17.5–18.2	17.8	24.3
Thickness mid-shaft	9.2–11.5	10.3	13.0

Scapula.—The scapulae correspond closely in general outline and as usual are of smaller size than are those of the Rancho la Brea, which makes the discrepancy in the adjacent clavicles all the more remarkable. The explanation probably is that the clavicles studied by Stock belonged to a very immature individual not more than four-fifths the size of the Yale specimen, which in turn is about nine-tenths the optimum.

SCAPULAR MEASUREMENTS

	Rancho la Brea		Yale
	Extremes	Mean	Y.P.M. 13198
Length glenoid cavity to suprascapular border, along the spine	236.0–246.0	237.6	222.0
Greatest width of blade at suprascapular border	249.6–272.7	257.5	225.0

Humerus (Plate II).—Here again the principal differences between the Yale humeri and those of the Rancho la Brea lie in an apparent age distinction in that the latter are much more rugged and robust, correlated with greater muscular development.

HUMERAL MEASUREMENTS

	Rancho la Brea No. 1874 R–1	Yale Y.P.M. 13198
Greatest length	432.4	387.0
Width at proximal tuberosities	106.2	94.2
Width at mid-shaft	55.3	52.8
Greatest width distal end	168.0	140.0

One generic distinction in *Nothrotherium* is the presence of an entepicondylar foramen which, while a characteristic of the Santa Cruz ground sloths, has been lost in all other Pleistocene genera. It is a primitive character.

Ulna and Radius (Plate II).—The distal end of our ulna differs from Stock's figures in having a distinct concavity for the reception of the cuneiform bone. It agrees, however, with his description.

There is no complete radius in the Rancho la Brea collection, so that the length as compared with ours is conjectural.

ULNAR MEASUREMENTS

	Rancho la Brea		Yale Y.P.M. 13198
	Extremes	Mean	Left
Greatest length	442.3–448.3	445.3	379.0
Width of mid-shaft	44.8–50.5	46.9	35.0
Greatest width of shaft at distal end	43.0–44.8	43.9	41.7

RADIAL MEASUREMENTS

Greatest length		ca. 415.0	340.0
Width mid-shaft	44.6–52.0	48.3	43.8

Manus (Pls. II, IV, V).—The manus in the Yale *Nothrotherium* are complete and add to our knowledge of this element, Stock's very accurate restoration erring in a perfectly understandable way. The very perfection of the manus and pes, in which the tendons, ligaments, and claws are *in situ,* obscures some details and makes detailed study of the individual bones impossible. X-ray photographs kindly taken by Dr. C. R. Scott of the Yale Medical School and here reproduced (Plate V) will aid in supplementing the description.

The manus has five digits of which the first and fifth, while complete and possessing claws, did not bear the creature's weight in walking on the knuckles. In the right manus of the Yale specimen, however, the outermost claw had apparently been lost during life, and the second phalanx is rounded off distally, having lost about half of its normal length. The digit is complete on the left hand but, were the right only known, one would be justified in the belief that the fifth digit was vestigial. Sesamoids are borne on digits II, III, and IV but not on I and V. The second claw is lighter and straighter than the third. The unguals are flexed at an angle of about 90° in the left manus with comparatively little flexion of the other articulations. The digits are united by the skin to about half the length of the second phalanx, so that little more than the claws are free. In their present condition the claws tend to converge toward their tips, a feature yet more marked in the pes. To what extent this is due to shrinkage of the soft tissue is not clear, but, in the foot at any rate, this convergence seems to be natural, not postmortem. The tip of the middle claw of the manus

is abraded, which may have been due in part to the fall into the pit and the subsequent struggle to escape.

To summarize: The chief additions to Stock's description are the presence of functional digits I and V. Digit V has about the same degree of reduction as in the Miocene *Hapalops,* with which it also agrees in having the metacarpal the longest of the five. The movement of this digit on the metacarpal is directed toward the axis of the hand, rather than toward the palm.

In the only known instance from the Rancho la Brea the trapezium is fused with metacarpal I. In the Yale specimen there is complete fusion in the left manus but not in the right, for, while the line of articulation shows distinctly, there was no movement between the elements. There is also a single metacarpal I from the Rancho without trapezium. It is evident, therefore, that this fusion is a variable feature, as with the Pleistocene genus *Mylodon.*

Pelvis.—The pelvis (Plate VIII) is preserved entire, save for the outer rim, which is absent except along the dorsal outline of the right ilium. This makes the ilia appear somewhat smaller than they should. The right ilium bears a portion of the hide with hair, the underlying tissue being much shrunken.

There is nothing to add to Stock's description.

PELVIC MEASUREMENTS

	Rancho la Brea 1891–1	Yale Y.P.M. 13198
Greatest transverse diameter across the ilia	ca. 846	ca. 672
Width of ilial wing measured parallel to posterior border	318	ca. 235
Length of posterior descending process of ischium from superior border to ventral symphysis	285	210
Dorso-ventral diameter of pelvic opening	222	182
Transverse diameter of pelvic opening	249	195
Width across posterior ends of ischia	346	275
Length of fused sacrals	231	220
Greatest transverse width of sacrum	ca. 238	217
Length of crest of fused dorsal spines	224	167
Height of dorsal crest, anterior end, from base of centrum	157	128

Femur.—The description of the femur also agrees in detail. Stock mentions a facet for the fabella. In our specimen the fabellae are both present, and in addition another flattened bone lies in the articulation between the outer condyle and the tibia, the outlines of which are obscured by tissue. These ossicles are both present in the existing tree sloth *Choloepus.* The knees of the Yale specimen are flexed at an angle of about 90°, and no attempt was made to straighten them in mounting the animal, as they are held rigid by the ligaments. The pose of the Rancho la Brea specimen differs from ours in this regard, but the Yale pose cannot be far from the habitual one.

I have compared the femora of our animal with that of *Morotherium gigas,* Y.P.M. 11898, Holotype. The latter is larger and more robust. It is also defective in outline. There seems to be no generic distinction between the two, but whether this element is sufficient to determine congeneric relationship, in which event *Morotherium* would take precedence over *Nothrotherium,* I am not prepared to say, in view of the inadequacy of the *Morotherium* type. There is in addition a fragment of humerus, but the two elements are insufficient.

FEMORAL MEASUREMENTS

	Nothrotherium		*Morotherium*
	Rancho la Brea 1871–1	Y.P.M. 13198	Y.P.M. 11898 holotype
Greatest length from head	397.7	341.5	429.0
Length from great trochanter	386.0	332.0	415.0
Width obliquely from great trochanter	186.0	ca. 155.0	223.0
Thickness of mid-shaft	49.3	38.0	51.0
Least width of mid-shaft	112.0	85.5	127.7
Greatest width, distal end	196.3	163.5	wanting

Tibia.—Less ruggedness characterizes the Yale tibiae as compared with those of the Rancho la Brea in conformity with comparative individual age.

TIBIAL MEASUREMENTS

	Rancho la Brea		Yale
	Extremes	Average	Y.P.M. 13198
Greatest length along mid-shaft	308.0–ca. 317.0	312.5	253.0
Greatest transverse width, proximal end	178.0–190.8	184.4	150.0
Greatest transverse width, distal end	129.8–142.8	136.3	79.0
Least width, mid-shaft	56.4–67.0	61.2	49.0

RATIO TIBIA TO FEMUR

	Rancho la Brea	Y.P.M. 13198	*Hapalops*
Nothrotherium shastense	0.796: 1		
Nothrotherium shastense		0.740: 1	
Hapalops longiceps			0.768: 1

Pes (Pls. II, VI, VII).—In the Yale specimen the right pes is complete, while the left lacks two phalanges of the vestigial digit V.

Stock speaks of the foot posture as resting *mainly* on the outer side (italics mine). The Yale specimen is held by ligaments so that the posture is established. The morphological sole of the foot is perpendicular to the ground. Thus the weight is borne

entirely on the outer margin and mainly on the fifth metatarsal, which is peculiarly shaped and must have been protected from impact by a thick, shock-absorbing cushion which is not preserved. The foot agrees with Stock's description in that the vestigial metatarsal I has fused with the entocuneiform, the remainder of the hallux having entirely disappeared. Stock says that metatarsal IV "supported apparently such rudimentary elements as are present in the corresponding digit of *Mylodon*." As a matter of fact digit IV is complete and bore a claw which, however, is smaller than that of digit II and much smaller than that borne on digit III. In the Yale specimen the entire digit IV in each foot is flexed sharply toward III, the axis being about 50° out of alignment with that of the metatarsal (see Plate VI, A, B). This deflection is apparently normal but may be somewhat exaggerated, due to tissue shrinkage, as the three claws are now in contact at their tip. The digits are enclosed in a common integument to near the base of the second claw but involving a portion of the third and fourth claws.

Stock says of metatarsal V that a facet at the distal end indicates the presence of a nodule. The Yale specimen shows not only one but two bones representing the first and second phalanges. The second of these is rounded at the tip and bore no facet. The appearance of the digit is quite similar to that of the fifth digit of the right manus (see above, p. 13), which I considered as probably accidental, as a claw is borne on the corresponding digit of the left manus. In view of the condition of the pes, however, it is possible that there was no accident to the right hand but a normal tendency toward the reduction of the digit, manifest in the right manus but not in the left.

There is quite a heavy pad on the base of each claw, somewhat larger in the pes than in the manus.

MEASUREMENTS OF PES

	Y.P.M. 13198	
	Right	Left
Length of foot, on chord to middle claw	291*	324
Length of foot, on curve	495*	427

* The right pes is flexed more than the left.

EXOSKELETON

Hide (Plate VIII).—Five areas of hide are preserved, on top of the head, on the right scapula, over three ribs on the right side in the wake of the scapula, on the right ilium, and at the base of the tail. That over the ilium averages 5 mm. thick. There is no trace of dermal ossicles or other armor. Hair is indicated on most of the patches of hide, but only on the ilium is it well preserved.

Hair (Plate VIII).—This is pale yellow in color, subcylindrical, smooth, fairly coarse and straight, about 45 mm. in average length on the rump. It must have formed

a good protective covering but is now very brittle. There is no trace of a woolly undercoat, as in the three-toed sloth. Whether it was uniform in length and distribution there is no means of knowing.

The claws are somewhat darker in color and, as the X-ray shows, are much larger than the bony core. They were inserted beneath the bony hood of the ungual.

MEASUREMENTS OF CLAWS

	Digit II	III	IV
Horn sheath of claw Y.P.M. 13198	96	125	88.5
Ungual phalanx without claw	Digit III		
Rancho la Brea	Extremes of four	Mean	
Greatest length, posterior end of posterior process to tip of claw process	158.4–165.8	161.8	

RESTORATION

(Pl. IX)

I HAVE attempted a tentative restoration modeled in plasticene, one-fourth linear dimensions, adhering to the posture of the mounted skeleton, except for two minor details. The tail has been straightened out and the hands pronated somewhat more, so that they rest fairly upon the knuckles. These adjustments could not be made in the mounted skeleton, as the shrunken tissues prevented. The posture is depressed behind somewhat more, I imagine, than in the normal walking gait. Otherwise I have followed the indicated morphology as accurately as I could.

The effect is somewhat weird, as the pictures show, with the extremely broad and powerful rear portion and the curious feet. One is impressed with the general utility of the fore limbs, not only in pulling down the branches of low trees and shrubbery but for digging and defense, since the claws, both front and rear, would be cruel weapons.

COPROLITE AND INFERRED FEEDING HABITS

THIS interesting relic has been analyzed by Prof. Arthur J. Eames, whose preliminary report, to be followed later by a more detailed statement, is as follows:

REPORT ON PLANT REMAINS IN SLOTH FOOD BALL

THE food ball consists of densely packed woody fragments of plants. The remains of small twigs constitute the bulk of the mass. With these stem bits are found frequent pieces of root.

Plant hairs, of two or three types, are abundant. The twigs and roots are of all ages from very young to at least three or four years. They tend to be crooked and branch freely.

Mingled with the remains is quartz sand in small amount. (The greatest care was taken to make certain that this sand was present normally in the center of the food ball and had not been introduced.)

The seed coats of a few very small seeds were present. No evidence of leaves could be found. No spines or thorns occur, and no heavy epidermal cells.

Digestion has removed from the twigs and roots all soft parts. The cortex, phloem, and the pith have to a large extent been removed.

The plants which make up the food ball are angiosperms and seem to be of the "sagebrush" type. They are freely branching shrubby types, in which the twigs were very slender. Apparently they were low, and the animal in browsing pulled them up at times by the roots and consumed the entire plant. The presence of frequent and even large roots can hardly be accounted for otherwise. The presence of sand can also be explained in this manner, though doubtless sand would occur on the twigs in a desert region.

The absence of leaf remains is puzzling. The plants may have been of leafless type, or have been without leaves when eaten. The abundance of very young twigs, however, suggests the growing season, and young foliage would doubtless be completely destroyed (so far as recognition goes) by digestion.

There are no remains suggesting fleshy or cactus-like types.

The material is all dicotyledonous and seems to belong largely or wholly to one or two genera. The wood structure, general anatomy, and hairs suggest that these genera may belong in the Compositae.

The few seed coats found, however, appear as though more likely to belong to the Chenopodiaceae. Further studies are necessary to determine even approximately the identity of these plants.

In summary: The sloth apparently was feeding upon low-growing, hairy, desert-scrub vegetation, such as at present grows in the southwestern United States. The plants appear to have been browsed coarsely, being cut into short pieces, often being pulled up by the roots and eaten entire. The stems were not crushed to appreciable degree. The fact that a large part of the twigs have less than one season's growth of wood suggests that the meal was made during the growing season of the plant. All evidence of the nature of the leaves has been destroyed by digestion.

The digestive process has removed nearly all of the cellulosic tissues, and it is evident that the "food ball" is a coprolite.

This would seem to imply as little climatic and vegetative change as topographic. The fact that the sloth ate roots as well as twigs shows that the inference that the claws were used for digging is doubtless correct. Tree sloths eat only the leaves and the three-toed one but two species of plant, the pumpwood, *Cecropia palmata,* and wild plum, *Spondias lutea* (Beebe, 1926). Our animal was evidently less particular and lived on such sustenance as the region afforded, except the cacti.

TAXONOMY

Order Xenarthra

Suborder Gravigrada

Family Megalonychidae

Subfamily Megalonychinae
Genus *Nothrotherium* Lydekker
Species *shastense* Sinclair

Generic characters, modified from Stock:

Skull elongate and subcylindrical; lachrymal prominent; malar vertically expanded with inferior process slender; frontal with large sinus; pterygoid with large posterior sinus opening inward. Lower jaw slender, with spout-like predental region and symphyseal ossicle. Dentition $\frac{4}{3}$, $\frac{4}{3}$. Last superior tooth semiquadrate in cross-section. Anterior caniniform teeth absent. Haemapophyses in middle part of tail X-shaped. Scapula relatively small. Manus with metacarpals longer and slenderer than in *Megalonyx;* pollex and digit V somewhat reduced, but all the digits bore functional claws. Ungual phalanx of digit II, manus, broad with convex dorsal surface. Wing-like posterior process of calcaneum longer than in *Megalonyx.* Astragalus resembles that of *Mylodon* and is more specialized than in *Hapalops* or in *Megalonyx* in adjustment to the rotation of pes to a position of rest on outer side. Metatarsal IV larger than in *Megalonyx;* metatarsal V with lateral wing-like process. Hallux somewhat reduced but bore a claw; digits II, III, and IV clawed and fully functional; digit V vestigial in pes.

No trace of dermal ossicles in hide.

Three species of North American nothrotheres have been described:

Nothrotherium shastense Sinclair 1905
Nothrotherium graciliceps Stock 1913
Nothrotherium texanum Hay 1916

In his 1925 memoir Stock abandons his species *N. graciliceps,* which was based upon a skull from the Rancho la Brea, and refers it, together with all of the Rancho la Brea nothrotheres, to Sinclair's species *shastense.* The Yale specimen under discussion is certainly conspecific with those from the Rancho la Brea, the variations from Stock's description as reviewed above being mainly those of age, as evidenced by size and relative slenderness, or such as fall within the range of variations exhibited by Stock's material.

Through the courtesy of the United States National Museum I have been able to make a direct comparison between our specimen and O. P. Hay's type of *Nothrotherium texanum* (Cat. No. 8353, U.S.N.M.).

The latter consists of an imperfect skull without the lower jaw, found at a depth

of forty feet in a well in Wheeler County, Texas. It belonged to an older individual than ours, more robust, with many of the sutures obliterated. In the *texanum* skull the limits of the temporal muscle area are clearly defined and the region itself is slightly rugose. There is no trace of this in the Yale skull. There is more modeling of the frontal area above in the former, and the lachrymal is more pronounced. The frontal foramen is farther forward, and the muzzle flares, as it does in certain Rancho la Brea skulls. The Texan skull is much broader than ours over the squamosals, whereas the frontals are more highly domed in the latter. The tooth row in the Texas skull is somewhat shorter, measuring 56 mm. to 58 mm. for the Yale specimen, as the last molar is slightly smaller.

Hay's specific distinctions from *shastense* are: Pterygoid bulla widely open below; anterior tooth with hinder margin transversely concave; hindmost upper tooth nearly as large as the others with a deep furrow on the hinder face. As the teeth are rootless and continually growing, they would probably change their proportions somewhat during life, and the other dental distinctions stressed by Hay seem hardly of specific value.

With regard to the pterygoid bullae, these are clearly imperfect, which makes the present opening much larger than it was originally. Where the actual margin of the aperture is preserved, as it is at the posterior end, it corresponds exactly with that of the Yale skull, and it is reasonable to suppose that, were the margin entire, the agreement would be complete. Hay himself expresses doubt as to this detail. Certainly the geographic localities are within the range of one species and possibly of one individual, if they were at all given to wandering. Stratigraphically no comparison can be made. My conclusion is that the *texanum* type is therefore conspecific with the Yale specimen and, like the latter, should be referred to *Nothrotherium shastense*.

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PLATES

PLATE I

Location of Sloth.

A. View of Aden Crater.

B. Looking west into the crater through the breach in the eastern wall of the rim. The opening into the sloth pit reaches entirely across the floor between the man on the left and the one on the right.

Photograph by Longwell.

C. Opening of sloth pit looking obliquely downward from the south side of the breach. The opening is somewhat foreshortened in the view.

Photograph by Longwell.

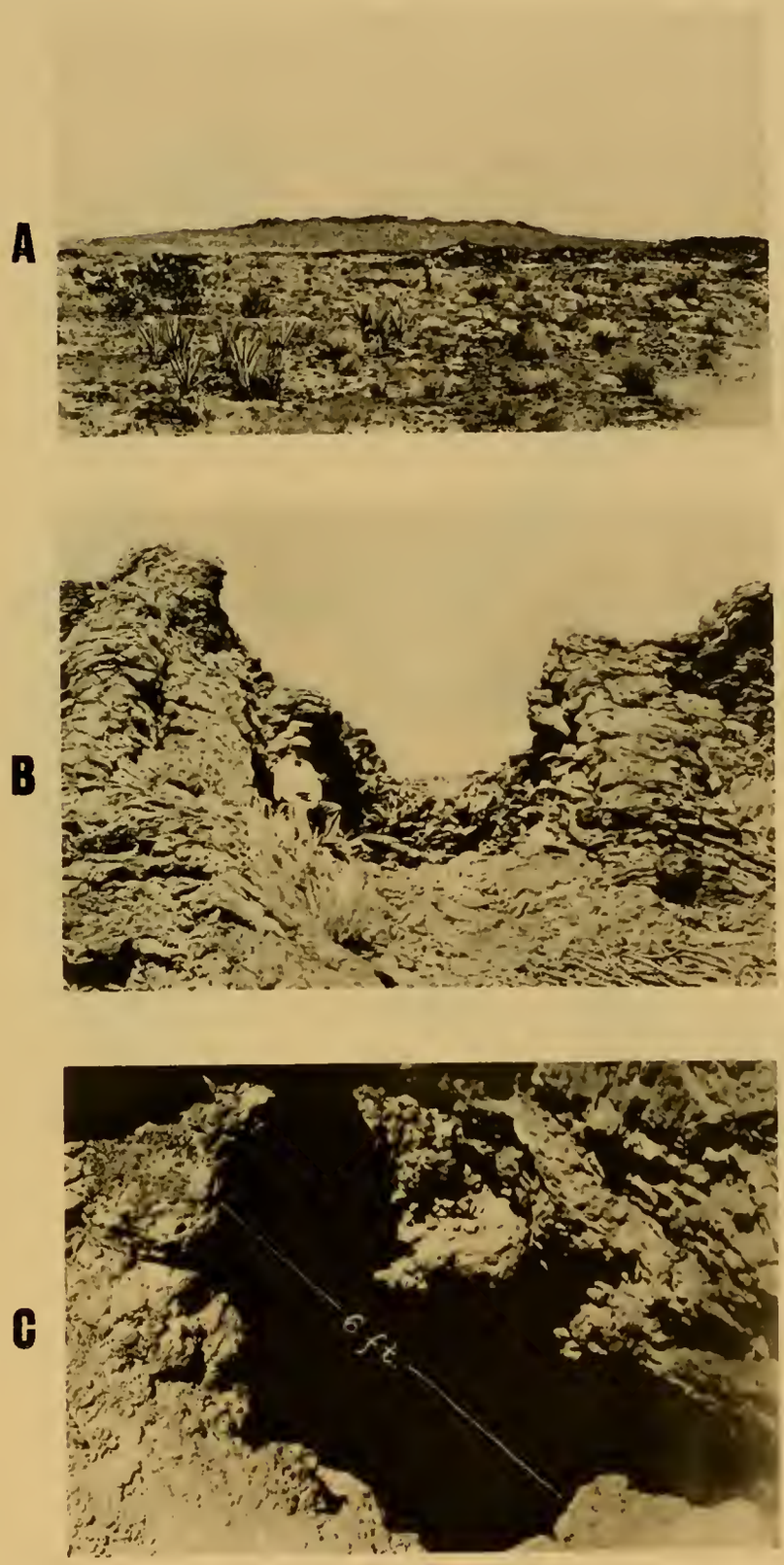

PLATE I—LOCATION OF SLOTH

PLATE II

Skeleton of *Nothrotherium shastense,* left aspect, about 1/9 natural size.

PLATE II—SKELETON OF *NOTHROTHERIUM SHASTENSE*, LEFT ASPECT, ABOUT 1/9 NATURAL SIZE

PLATE III

Skull of *Nothrotherium shastense.*

A. Lateral aspect showing portion of hide. Tooth marks of a rodent visible on the margin of the hide.
B. Palatal aspect.
C. Mandible.
About 1/3 natural size.

A

C B

PLATE III—SKULL OF *NOTHROTHERIUM SHASTENSE*

PLATE IV

Manus of *Nothrotherium shastense.*

A. Right manus, palmar aspect, digit V apparently vestigial, probably premortem injury.
B. Left manus, palmar aspect, missing hallux present, but removed by a spectator.
C. Right manus, inner aspect, hallux claw sheath missing.
D. Left manus, outer aspect.

About 3/8 natural size.

PLATE IV—MANUS OF *NOTHROTHERIUM SHASTENSE*

PLATE V

Skiagraph of right manus.

A. Inner aspect.
B. Palmar aspect.
3/4 natural size.

PLATE V—SKIAGRAPH OF RIGHT MANUS

PLATE VI

Pes of *Nothrotherium shastense.*

A. Right pes, inner aspect, the morphological sole, showing vestigial Vth digit.
B. Left pes, outer aspect, position reversed in photographing so that the astragalus is downward.

About 2/7 natural size.

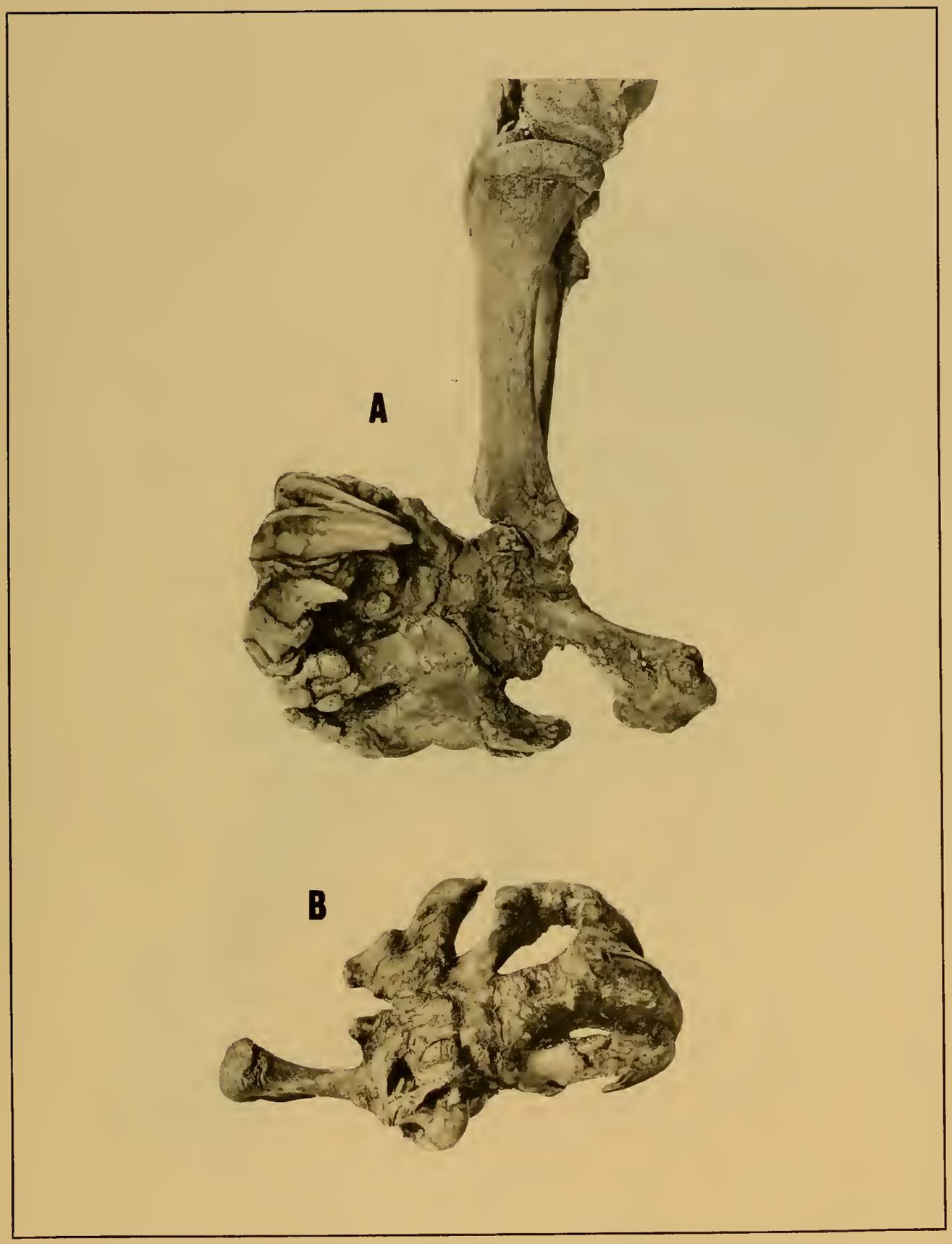

PLATE VI—PES OF *NOTHROTHERIUM SHASTENSE*

PLATE VII

Skiagraph of left pes obliquely from above, 3/4 natural size.

PLATE VII—SKIAGRAPH OF LEFT PES OBLIQUELY FROM ABOVE, 3/4 NATURAL SIZE

PLATE VIII

Right hip of *Nothrotherium shastense,* showing hide and hair *in situ.* The tooth marks of a rodent are visible on the margin of the hide.

PLATE VIII—RIGHT HIP OF *NOTHROTHERIUM SHASTENSE*, SHOWING HIDE AND HAIR *IN SITU*

PLATE IX

Restoration of *Nothrotherium shastense,* based upon the Yale specimen. By R. S. Lull. About 1/10 natural size.

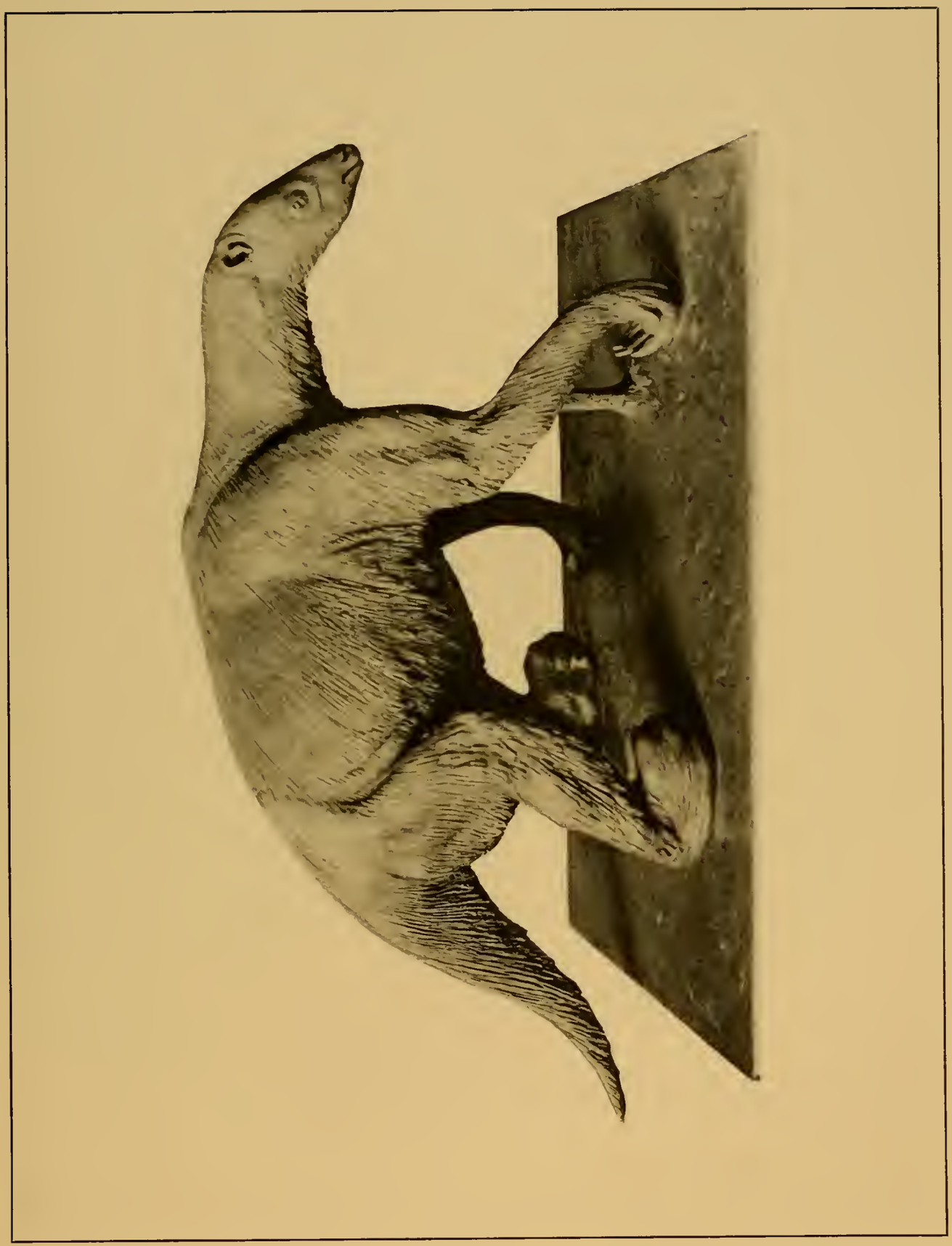

PLATE IX—RESTORATION OF *NOTHROTHERIUM SHASTENSE*, BASED UPON THE YALE SPECIMEN. BY R. S. LULL. ABOUT 1/10 NATURAL SIZE

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